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SIMULATED COLD WEATHER RADIOLOGICAL DECONTAMINATION OF RECOVERY EQUIPMENT

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by

Alfred E. Hanna

ABSTRACT

The U. S. Naval Civil Engineering Laboratory was requested to develop suitable AW decontamination materials, equipment, and techniques for use in temperatures down to minus 10 degrees F. Tests were conducted in NCEL's Cold Chamber, in which compressed air, steam, vacuum, water, and antifreeze solution were used to remove a fluorescent fallout simulant from a large tractor. It is concluded that antifreeze solution and water, if warmed, are the most effective materials; steam may be acceptably effective, and air and vacuum have limited use. Additional work is recommended.

INTRODUCTION

The problems involved in radiological decontamination have been investigated by many agencies. These investigations were, until rather recently, concerned mainly with decontamination effort under temperate weather conditions. Not much concern was given to cold weather decontamination of ground surfaces and buildings, and even less to the decontamination of equipment which would be required for any major recovery effort.

The Naval Civil Engineering Laboratory had been given the responsibility for developing suitable decontamination methods for use under sub-freezing conditions, and conducted a series of equipment-decontamination tests in its Cold Chamber Facility. The methods by which a fallout simulant was removed from a D8 tractor included washing with water or antifreeze solution, blowing a fallout simulant off with steam or compressed air, and vacuuming the tractor.

MATERIALS AND EQUIPMENT

Fallout Simulant

The ideal substitute for true fallout would be a radioactive material which could be detected readily with standard survey instruments. Since unconfined radioactivity was not practical for this investigation, fluorescent materials were used. A commercially obtained solution of two fluorescent chemicals was selected, and required only further dilution with toluene for use. Monterey sand (150-300 microns) was poured into the dilute solution until all the liquid appeared to be absorbed. The toluene was removed by evaporation, leaving the sand dry and coated with the fluorescent mixture before use.

Spreading Assembly

The assembly shown in Figure 1 and diagrammed in Figure 2 was devised to help simulate the action of descending fallout particles. The simulant was placed in the hopper A. Compressed air at 90 pounds per square inch was passed through the line B, creating a suction at the nozzle C. The suction drew sand from the hopper A and air from the opening D through the line E. The resulting sand-air mixture was blown at the bottom of a concave-curved, cast-iron surface F. A second compressed air stream G (at 90 pounds per square inch) was directed through a small opening H into the sand-air stream. The latter action resulted in a much greater dispersion of

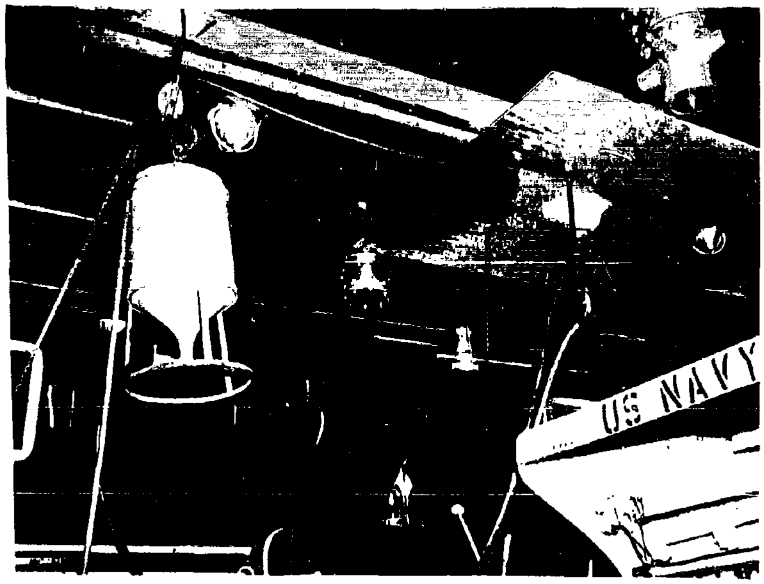

Figure 1. Spreader assembly in Cold Chamber.

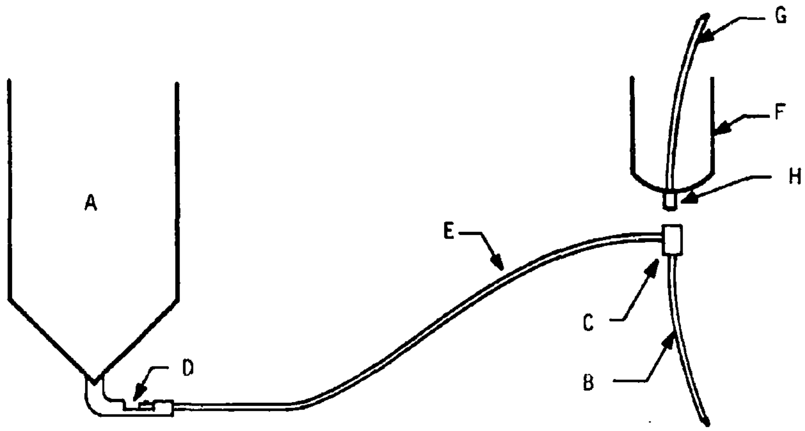

Figure 2. Diagram of spreader assembly.

the sand than would have been obtained if the sand-air stream were impacted directly against the cast-iron surface. The entire assembly was suspended from a wooden frame; a plywood shield prevented the sand from pitting the stainless steel ceiling of the Cold Chamber.

Vacuum

A small, shop-model vacuum cleaner was used in the removal of fluorescent simulant from the tractor. A wide brush attachment was used for most flat surfaces; extension tubes were used to reach less accessible areas. A flat nozzle was used for crevices and similar locations where the extension tubes or the brush could not be used effectively. The attachments were similar to those supplied with most household vacuum cleaners, except for being larger.

Steam

A Cyclotherm steam generator, part of the Cold Chamber Facility, provided the steam used in these tests. The generator had a capacity of 620 pounds of steam per hour. The steam as used was at a pressure of 80 pounds per square inch.

Compressed Air

A Westinghouse Model 6032 air compressor, also part of the Cold Chamber Facility, supplied compressed air. The compressor, a two-stage, air-cooled unit, had a rated capacity of 43.2 cubic feet per minute at 80 pounds per square inch. During decontamination tests, air at 60 pounds per square inch was used. The external piping was arranged so that a common line was used for both compressed air and steam inside the chamber. The same nozzle was also used for both. A portable air compressor was obtained to provide the second air stream required during spreading operations.

Water

The water used in decontaminating came directly from local mains. Its temperature was approximately 65 F, and it was at a pressure of approximately 40 pounds.

Antifreeze Solution

Stock antifreeze was obtained and mixed with water in the ratio of three gallons of antifreeze to five gallons of water, to obtain a freezing point of -12 F. The solution was mixed and stored just outside the chamber in a Model M8A2, 200-gallon capacity decontamination wagon. In addition to a pump and hose, the wagon was equipped with an adjustable hose nozzle which could deliver any stream from a solid stream to a spray, as might be desired. The adjustable nozzle was also used on the water line.

Fluorimeter

The original plans for this investigation included the development of a fluorimeter which would measure the fluorescence induced by ultraviolet light of known characteristics. Proper filters and heat-absorbing glass were not received in time to make the device and use it in these tests.

PROCEDURE

The spreader assembly was installed in the Cold Chamber and a D-8 tractor (Figure 3) was driven into the chamber and underneath the spreader. The chamber doors were closed and the temperature of the chamber was reduced to -10 F. The two compressed air streams were turned on and the fluorescent material was distributed over the tractor. After five minutes the air streams were turned off, the lights in the Cold Chamber were turned out, and an ultraviolet light source was used to check the distribution of simulant over the tractor. The chamber lights were also extinguished after each decontamination step and the ultraviolet light used to check the degree of decontamination.

RESULTS

Only qualitative results were obtained in these tests, as the fluorimeter could not be built in time for use.

Vacuuming

The simulant was apparently removed without difficulty from all readily accessible surfaces and from those points within reach of the extension tubes and nozzle. This was true for removal of simulant from dry or icy surfaces, but simulant frozen in or under ice could not be removed by this method.

When the tractor was re-examined under the ultraviolet light after decontamination, a number of crevices were found where vacuuming had not been successful. These were primarily among the control levers and under metal plates beneath the operator's seat.

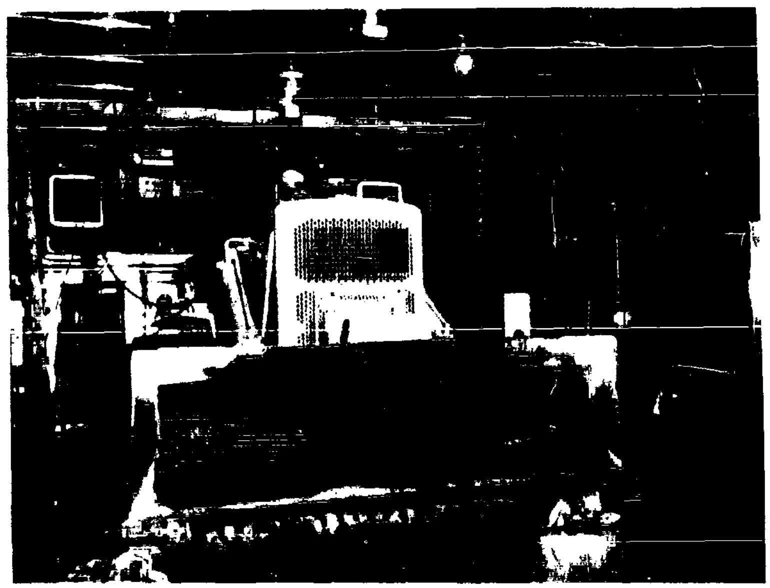

Figure 3. Tractor in Cold Chamber under spreader assembly.

Steam

A very dense fog, formed when steam was used, prevented complete decontamination. The working crew had great difficulty in telling where the steam was hitting, and a greater problem in determining how effectively, except when viewing from very close range. Under such circumstances there was a possibility of personnel becoming contaminated from blown-back material or through accidental contact with a contaminated surface. Personnel were checked in all cases where contamination might have occurred, but none was detected.

Steam was effective in removing simulant under all three surface conditions (simulant from a dry surface, from an icy surface, and frozen in ice) by blowing away loose material and by melting ice and then blowing away both water and simulant. Some simulant was blown into small crevices from which it was not readily removed. The steam nozzle could reach parts of the tractor which were inaccessible to vacuum, but had to be fairly close to the surface to be effective.

Temperature in the chamber rose very rapidly when steam was used. When the cooling fans were turned on the refrigeration coils began to frost over seriously. Subsequently the fog condensed, froze, and steeled on the chamber floor and the tractor as soft, pellet-like snow.

Compressed Air

Compressed air was effective in removing simulant from dry or icy surfaces if the simulant did not adhere to the ice. It was completely ineffective in removing simulant that was frozen in or under ice. As with steam, there was some possibility of the particles being blown onto the workers, although none was detected. Compressed air was not effective unless the nozzle could be brought fairly close to the area being decontaminated.

Water

Water was effective in removing simulant from all locations on the tractor where it could be detected. Crevices and other areas not normally reached in the previously discussed tests (air, vacuum, steam) were decontaminated. There was danger that splash-back-borne simulant might contaminate the workers. The water froze quite rapidly when it stopped moving, but became fluid again when contacted by warmer oncoming water. The large amount of water vapor present rapidly coated the refrigeration coils, especially after the cooling fans were turned on.

Antifreeze Solution

The antifreeze solution proved to be a very effective decontaminating agent, producing results that were equal to those obtained when water was used. In addition, since the solution was compounded for -12 F, it did not freeze on the tractor. It was thus possible to examine the tractor after each decontamination step and further decontaminate unsatisfactory areas without having to thaw ice. The solution did not freeze until it had become thoroughly diluted by ice it had melted or that had formed on the chamber floor.

DISCUSSION

Vacuuming was moderately successful on two of the three types of surfaces. Decontamination personnel would have to work as near to the contaminated vehicle as with compressed air or steam, but there would be less chance of personnel contamination. The receptacle for the vacuum system would require shielding to minimize the radiation hazard to personnel.

Use of either compressed air or steam presented certain difficulties. With both, the nozzle had to be quite close to the surface, and even then cleaned off only a limited area. However, the steam could melt fallout-bearing ice, and in this regard is preferable to air. In addition, the dense fog which formed when steam was first used should not be such a problem in a field application. Although the steam would condense in the field, natural air circulation should be adequate for removing the fog from the working area.

Perhaps the main disadvantage in using either water or antifreeze solution was that the moving fluids carried simulant to points that were not contacted by naturally-settling materials. While many of these points were located, it must be assumed that some were not detected. Radioactive fallout would, of course, be detected by survey instruments. The mass of each fluid, and the force imparted by its velocity proved effective in removing simulant from areas inaccessible to the vacuum, steam or compressed air. The splash-back which occurred frequently with either water or antifreeze was a potential source of personnel contamination. None of the fluorescent simulant was detected on the task crew, although their outer garments became quite damp from the splatters.

The temperature of both solutions raises some question about their effectiveness. As stated previously, the water came directly from local mains, and the antifreeze solution from a decontamination wagon parked just outside the Cold Chamber.

The water temperature was about 65 F, and that of the antifreeze solution was about 72 F. No cooling surface was provided other than that of supply hoses lying on the Cold Chamber floor. The water formed a thin glassy film on all surfaces within seconds after the main stream was moved away, but readily remelted as soon as additional fresh water was hosed on. Water in mains in a cold region would be only a few degrees above freezing; the ice film would form more rapidly, would be thicker, and would be remelted more slowly than that formed in this test.

The antifreeze solution, since it was compounded for -12 F service, froze only when it had become well-diluted. Nevertheless, its initial temperature accounted for a great part of its effectiveness in removing simulant on and in ice layers.

These higher temperatures could, in practice, be duplicated by contact between incoming water and heating coils in some kind of portable reservoir. A second possibility is an injection system where live steam from a portable plant would be passed directly into the fluid stream.

A fluorescent material is not the best simulant for radioactive fallout. To obtain a certain mass deposit level the material might have to be as a layer several grains in thickness. The ultraviolet excitation would not penetrate past the equivalent of a uniform layer of material, and only that equivalent layer would fluoresce. On the other hand, the gamma radiation from the top layer of a radioactive simulant would be fortified by radiation from underlying layers. Radiation from the bottom of the deposit would not be affected appreciably by overlying material. Thus one might have equal deposits of material but not have comparable radiation levels.

The selection of a fluorescent rather than a radioactive material was dictated by necessity. It would not be possible to use a radioactive material in this test without thoroughly contaminating the Cold Chamber. It was also anticipated that some of the radioactive material would be picked up and discharged while the antifreeze solution and water were being removed during cleanup operations.

CONCLUSIONS

Certain conclusions may be drawn on the basis of this test:

1. Vacuum and air are effective in removing fallout under certain conditions specified in this report. Neither is effective in removing fallout frozen in or under ice.

2. Steam may be acceptably effective in removing fallout in a field situation, if the fog generated by its use is rapidly dispersed.

3. Warmed water and antifreeze solution are most effective in decontaminating vehicles under all surface conditions. The antifreeze solution makes it possible to examine the vehicle and decontaminate it further with less effort than does water.

4. The difference in characteristics of ultraviolet and gamma radiation render it difficult to obtain quantitative data using a fluorescent material. Even so, its use for tests such as these is preferable as a result of problems inherent in contamination of the chamber and in recovery and final disposal of a radioactive simulant.

RECOMMENDATIONS

The following are recommended:

1. Conduct further tests in NCEL's Cold Chamber incorporating:

a. smaller vehicles, such as D-6 tractor and smaller earth-moving equipment, jeep, weapons carrier, etc.

b. water and various concentrations of antifreeze solution as the decontaminating agents

c. an intermediate cooling system to vary the temperature of the fluids between local ambient temperature and that representative of water supply in a cold region.

2. Conduct cold weather field tests on decontaminating larger equipment which would be used in recovery efforts, with a radioactive material as the contaminating agent.

3. Find or develop a system by which live steam from a portable generator could be injected into a cold fluid stream.

4. Investigate heating coils and tanks that might be used in the field for heating water or antifreeze solutions.

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